



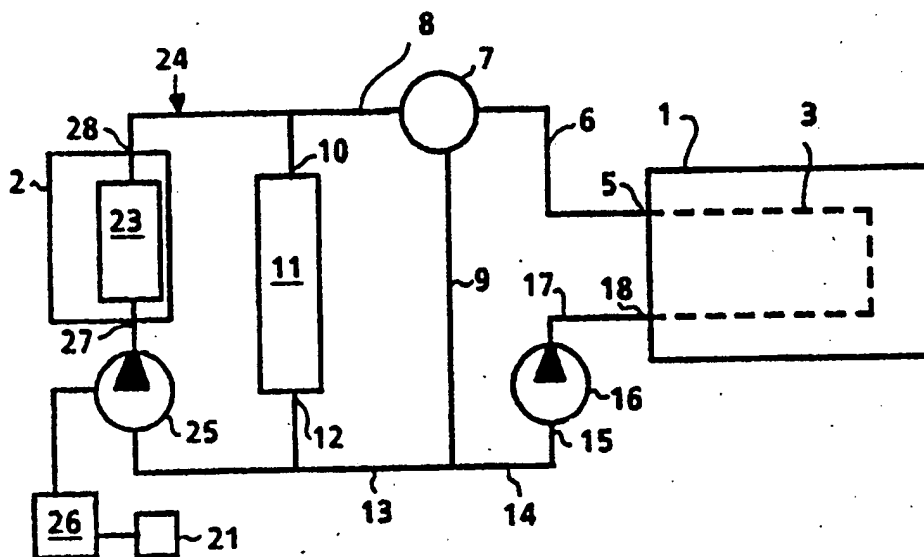
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: COOLING SYSTEM FOR A VEHICLE EQUIPPED WITH A RETARDER

## (57) Abstract

A cooling system for a vehicle equipped with retarder incorporates an engine cooling circuit, a retarder cooling circuit and a radiator (11) which is common to both circuits. The retarder cooling circuit (24), which is arranged in a circuit parallel with the radiator (11), incorporates a retarder cooler (23) and an extra cooling medium pump (25). This cooling medium pump (25) is operated separately and is arranged to operate during the time when the retarder (2) is activated. The fact that the retarder cooling circuit (24) is connected substantially directly to the radiator (11) eliminates the problems which are due to the presence in the engine cooling circuit of a thermostat and to the presence in the engine cooling circuit of a cooling medium pump (16) which depends on the engine speed.



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## Cooling system for a vehicle equipped with a retarder

This invention relates to a cooling system according to the preamble to patent claim 1.

### State of the art

Cooling systems for a water-cooled combustion engine for vehicle use usually incorporate a radiator and a cooling medium pump, driven mechanically by the engine, for circulating the cooling medium through the radiator and the engine cooling ducts. In addition there is in parallel with the radiator a pipe via which the cooling medium can bypass the radiator if the cooling medium temperature is low. The flow through the bypass pipe is usually controlled by means of a thermostat.

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In cases where the vehicle, e.g. a heavy duty truck or a bus, is equipped with a supplementary brake, a so-called retarder, e.g. a retarder of hydraulic type, it is usual for the latter to be cooled by means of a retarder cooler which is connected to the ordinary cooling system of the engine. As the retarder is situated in the vehicle transmission at the rear end of the engine, the easiest way of connecting the retarder cooler is in series between the outlet of the engine cooling ducts at the rear end of the engine and a pipe connected to the thermostatically controlled inlet of the radiator. Such a connection arrangement has the advantage that the ordinary cooling system does not have to be modified to any major extent. It is also a solution which makes it easy to incorporate a retarder cooler into existing vehicles even if the cooling system was not originally designed with this in mind. This solution does however have the disadvantage that all of the cooling medium which flows through the retarder cooler must also pass through the thermostat. A braking operation generates large amounts of heat in the retarder which have to be removed quickly via the retarder cooler. It only takes some few seconds for the cooling medium to heat up locally in the retarder cooler to boiling temperature, which should be compared with the fact that it usually takes some minutes for the thermostat to open fully from a fully closed position. A further factor to be noted is that the cooling medium pump is usually driven mechanically by the engine, with the result that its capacity depends on the engine speed. At the time of a braking operation, it is natural for the driver to release the accelerator and the engine brakes, resulting in the engine speed decreasing as the vehicle speed declines, with consequently lower pump capacity. All this leads to a risk of the cooling medium boiling at the time of retarder braking.

A known way of attempting to reduce this risk is to adopt during retarder braking a special driving technique consisting in the driver changing down before braking, with a view to increasing the engine speed and hence increasing the capacity of the cooling medium pump. Another way is to reduce the braking capacity of the retarder so that a smaller amount of  
5 heat is developed in it, but this has at the same time the effect of reducing the usefulness of the retarder.

A way of compensating for the reduced pump capacity at low engine speeds which is known, e.g. from US 5 095 855, is to incorporate a further cooling medium pump in the cooling  
10 system. This extra pump is driven electrically and is connected in series with the ordinary cooling medium pump but is only operated when the cooling medium temperature exceeds a certain temperature. In a cooling system without a retarder cooler, this solution does perhaps function as intended, but if this solution is employed in a cooling system with a retarder cooler, a possibility which is not mentioned per se, the abovementioned  
15 disadvantages remain. The extra pump is operated according to the cooling medium temperature, with the result that this cooling system will likewise react too slowly to the rapid temperature changes which take place on activation of the retarder. The cooling medium is likely to start boiling significantly sooner than the pump can start influencing the cooling medium circulation. If moreover the cooling system incorporates a wax type  
20 thermostat as commonly used for cooling systems, this is far too slow to redirect the whole flow to the radiator before boiling occurs locally in the retarder cooler.

A further characteristic of known systems is that the braking capacity of the retarder may be nil or severely reduced if the cooling of the retarder ceases to function. This may happen, for  
25 example, if the engine stops and the operation of the cooling medium pump therefore ceases. Although the retarder is often regarded as an extra brake intended to supplement the vehicle's ordinary brakes, it also constitutes an extra brake which can be used as an emergency brake in cases where the ordinary brakes cease to function. Known cooling systems which incorporate retarder coolers and engine-driven cooling medium pumps do  
30 however exhibit the disadvantage that the retarder has no braking capacity if the engine stops, thereby nullifying the possibility in practice of using the retarder as an emergency brake.

**Object of the invention**

It is an object of this invention to eliminate or at least substantially reduce the disadvantages which characterise the known solutions in which a retarder cooler is incorporated in an engine cooling system. One object is therefore to ensure proper cooling and prevent risk of local boiling in the retarder cooler even when the engine is operating at low speed and the retarder is used for vehicle braking. Another object is to facilitate optimum and effective use of the retarder without having to deliberately reduce its braking capacity because of the risk of boiling. A further object is to make it possible to achieve optimum design of the cooling system with regard to the ordinary cooling requirements of the engine when the retarder is not being used. In addition, the cooling system should be simple and inexpensive and not require any more extensive modifications of other components of the cooling system in cases where it is supplemented by a retarder cooler.

Another object of great significance is to make it possible in a multiplicity of operating circumstances to use the retarder as an emergency brake when the ordinary brakes of the vehicle cease to function.

**Brief description of the invention**

According to the invention, the objects stated above are achieved by the cooling system being designed with the features which are indicated in the characterising part of patent claim 1. Operation according to the invention of the second pump in correlation with activation of the retarder makes it possible for an increased cooling medium flow to start immediately, before the cooling medium temperature rises. The result is a greater margin before the risk of boiling arises. Placing the second pump and the retarder cooler in a separate circuit makes this circuit independent of the ordinary thermostat. The result is to eliminate completely the disadvantages which are due to the slowness of the thermostat, and also to eliminate the pressure drop which the thermostat causes. In a conventional cooling system with a wax type thermostat it is not unusual for the thermostat to be responsible for half of the pressure drop of the whole cooling system. This means that half of the energy consumed for operating the pump is only used to overcome the pressure drop due to the thermostat. A direct consequence of the invention is that there is no need for the dimensioning of the second pump to take the pressure drop due to the thermostat into account.

Using a separately operated pump for the circulation of cooling medium through the retarder cooling circuit makes this circulation independent of engine operation. The retarder can therefore be used for braking even if the engine stops.

- 5 In an advantageous embodiment of the invention, the second pump and the retarder cooler are placed in a separate cooling circuit which is parallel with the radiator. This embodiment is easy to apply to an existing cooling system, as it involves no major encroachment on the other cooling system. It is also possible to dimension the cooling system according to the cooling requirements of the engine without having to take appreciably into account the  
10 influence of the retarder cooler and the second pump.

- In another advantageous embodiment, the retarder cooler is placed in a pipe which is also incorporated in the cooling circuit of the engine and which therefore has cooling medium flowing through it at all times during normal operation of the engine. In this case the cooling  
15 medium which is led to the cooling ducts of the engine will pass first through the retarder cooler. This embodiment makes it possible for the retarder, through being controlled according to a special programme during starting of the engine, to be used to speed up the warming up of the engine. In this case the retarder is connected so as to perform braking work at the same time as the engine is operation at a load, with the result that the heat  
20 generated in the retarder raises the cooling medium temperature, which in its turn quickly raises the engine temperature to normal operating temperature.

Further advantages and characteristics distinguishing the invention are indicated in the following description, which exemplifies two embodiments of the invention.

### List of figures

The description is given with reference to the attached schematic drawings of the engine cooling system, which incorporates a second cooling medium pump and a retarder cooler.

Fig.1 shows an embodiment in which the second pump and the retarder cooler are placed  
5 in a separate circuit, and

Fig.2 shows an alternative embodiment in which a second pump is incorporated in the same cooling circuit as the ordinary cooling medium pump of the engine.

### Description

10 Fig.1 depicts schematically a cooling system for a combustion engine 1, e.g. a diesel engine used for powering a heavy duty vehicle such as a truck or a bus. In the engine there are cooling ducts 3 which form part of the engine cooling medium circuit and have cooling medium flowing through them with a view to cooling the engine. The cooling medium consists of a liquid which advantageously consists of a mixture of water and glycol. An  
15 outlet 5 from the engine cooling ducts 3 is connected via a first pipe 6 to a thermostat housing 7 which contains a thermostat, i.e. a valve controlled by the cooling medium temperature. The thermostat housing 7 is in its turn connected both to a second pipe 8 and to a bypass pipe 9. The second pipe 8 is connected to the inlet 10 of a radiator 11 whose outlet 12 is connected via a third pipe 13 and a fourth pipe 14 to the inlet 15 of an ordinary  
20 cooling medium pump 16 which is driven mechanically by the engine. An outlet 17 from the cooling medium pump 16 is directly connected to an inlet 18 of the engine cooling ducts 3. The aforesaid bypass pipe 9 is connected not only to the thermostat housing 7 but also to a connection between the third pipe 13 and the fourth pipe 14 and thus constitutes a line which runs parallel with the radiator 11 and allows cooling medium to bypass the radiator 11 in a  
25 manner dependent on the action of the thermostat contained in the thermostat housing 7. The ordinary cooling medium pump 16 is driven mechanically by the engine crankshaft and its capacity depends accordingly on the operating speed of the engine. The cooling system as so far described constitutes an engine cooling circuit which is conventional for present-day engines.

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In this case the vehicle is equipped with a retarder 2, which is a supplementary brake connected to the vehicle transmission. In this embodiment the retarder 2 is of hydraulic type, which means that the braking effect is created by the hydraulic fluid of the retarder being

forced to circulate in it under resistance. The result is that at the time of braking the hydraulic fluid will absorb the heat which is generated during a braking operation and which causes a rapid rise in the temperature of the hydraulic fluid. With a view to removing heat from the hydraulic fluid by means of the engine cooling system and its radiator 11, the

5 retarder 2 incorporates a retarder cooler 23 which in practice consists of a heat exchanger arranged between the hydraulic fluid of the retarder 2 and the cooling medium of the cooling system. The retarder cooler 23 is incorporated in a separate retarder cooling circuit 24 which is parallel with the radiator 11 and which also incorporates an extra cooling medium pump 25. This cooling medium pump 25 is operated separately, which means that its

10 capacity is independent of the vehicle engine operating speed or other engine parameters. In this embodiment the pump 25 is driven by an electric motor which operates under the influence of an electrical control system 26. Alternatively the pump 25 may be driven by a hydraulic motor. The control system 26 is also connected to a sensor 21 associated with the retarder 2 with a view to the control unit 26 indicating whether the retarder is activated or

15 not. The pump 25 is advantageously of displacement type, e.g. of wing pump type, which has the advantage that the pump 25 at standstill also prevents cooling medium flow through the retarder cooling circuit 24. The outlet of the pump 25 is connected to the inlet 27 of the retarder cooler 23 but may alternatively be connected to the retarder cooler outlet 28. The retarder cooling circuit 24 also incorporates pipes for respective connection to the engine

20 cooling system at a connection between the outlet 12 of the radiator and the third pipe 13 and at the inlet 10 of the radiator 11.

The function of the cooling system described is as follows. It is initially assumed that the radiator 2 is not activated and that the extra cooling medium pump 25 is not running. This

25 pump 25 will therefore block flow through the retarder cooling circuit 24. However, the ordinary cooling medium pump 16 will, to an extent depending on the operating speed of the engine 1, circulate cooling medium through the engine cooling circuit, i.e. through the engine cooling ducts 3 and on to the thermostat housing 7, from which it goes on, depending on the cooling medium temperature, through the radiator 11 or the bypass line 9 or dividedly

30 through both. In these circumstances the cooling system operates conventionally and the retarder cooler 23 and the extra pump 25 exert no influence of any kind. When the vehicle driver activates the retarder 2 and the latter conventionally provides braking, the control unit 26 receives from the sensor 21 an indication thereof, with the result that the extra cooling

medium pump 25 starts running substantially simultaneously with the activation of the retarder 2. Cooling medium will then be drawn in from the outlet 12 of the radiator 11 and be pumped through the retarder cooling circuit 24 with the retarder cooler 23 and back to the radiator inlet 10. At the radiator inlet 10, cooling medium which has passed through the engine cooling ducts 3 will, assuming that the thermostat is open, be merged with cooling medium from the retarder cooler 23 so as to form a common flow through the radiator 11. If the capacity of the extra pump 25 substantially exceeds that of the ordinary pump 16, a major proportion of the flow from the retarder cooler 23 will also be led to the radiator 11. This may cause somewhat impaired cooling of the cooling medium from the engine cooling ducts 3. However, as the engine runs at low load during a braking operation and therefore generates a relatively small amount of heat, this factor is not critical for the engine during the time which the braking operation takes. It is advantageous for the two cooling medium pumps 16, 25 to be dimensioned with regard to capacity and pressure so that there is optimum circulation through the retarder cooling circuit 24 and the engine cooling circuit in at least the majority of operating conditions. This means inter alia that the extra pump 25 should not give rise to any backflow in the engine cooling circuit at normal engine speeds and should preferably also permit sufficient cooling of cooling medium from the engine cooling circuit.

Cessation of retarder braking is detected by the sensor 21, whereupon the control unit 26 may switch off the extra pump 25. In principle the extra pump 25 should be arranged to operate during the period when the retarder 2 is activated, but it may be more advantageous to allow the pump to operate for a further period, since the cooling medium temperature after braking may be high. It is also possible that the driver may activate the retarder again shortly afterwards, which might cause a number of repeated switchings on and off. For these reasons the control unit 26 incorporates control devices which keep the pump 25 operating for a certain predetermined time, of the order of 30 seconds to some minutes, after retarder activation has ceased. Alternatively the control unit 26 may be connected to devices which detect the cooling medium temperature in order to switch the pump off when the cooling medium temperature falls below a certain temperature.

Activation of the retarder 2 is detected by the sensor 21, which influences the control unit to activate the extra cooling medium pump 25. This leads to cooling medium from the outlet

28 of the retarder cooler 23 being caused to flow through the retarder cooling circuit 24 and directly to the radiator inlet 10. This flow is therefore entirely independent of the thermostat contained in the thermostat housing 7. The cooling medium will thus be cooled as much as is possible in the radiator 11 even if its temperature is initially low. This cooling of the cooling medium reduces the risk of boiling arising from the development of heat in the retarder. When the retarder 2 in connection with a braking operation starts to give off heat in the retarder cooler 23, the cooling medium is partly cooled down and also the cooling medium flow through the retarder is high because of activation of the extra pump 25.

- 10 With a view to enhancing this function, the invention may in a modified embodiment be arranged so that the driver can immediately activate the extra pump 25 manually, e.g. if the cooling medium temperature is abnormally high.

Fig.2 depicts an alternative embodiment of the invention which incorporates the same components as mentioned above but arranged in an alternative manner. The components therefore have, wherever possible, the same reference notations as used above. The principal distinguishing feature of the embodiment according to Fig.2 is that the retarder cooler 23 is situated in the fourth pipe 14, i.e. the pipe between the radiator outlet 12 and the inlet 15 of the ordinary pump 16, which pipe 14 also forms part of the engine cooling circuit. In this case, however, the extra pump 25 is situated in a separate pipe 31 between the retarder cooler outlet 28 and the radiator inlet 10. The pipe 31 also incorporates a check valve 32 intended to prevent cooling medium flow in the reverse direction when the pump 25 is not activated and in cases where the pump 25 is not of displacement type. The check valve 32 may of course also be used in conjunction with a pump of displacement type to further ensure that no cooling medium passes through the pump 25 in the wrong direction. If the pump is of displacement type, however, the check valve 32 may normally be omitted. For the same reason, the cooling system depicted in Fig.1 should also be supplemented by a corresponding check valve if the pump 25 is not of displacement type.

- 30 The function of the embodiment depicted in Fig.2 is substantially the same as that described above with reference to Fig.1. When the retarder 2 is not activated, the extra pump 25 is not activated either. Flow of cooling medium through the pipe 31 is prevented by the pump if it is of displacement type, and also, in the present case, by the check valve 32. In a similar

manner to that described above, cooling medium is pumped by the ordinary pump 16 through the engine cooling ducts 13 and on to the thermostat housing 7, from which it goes on to the radiator 11 and/or the bypass pipe 9, depending on the cooling medium temperature. Thereafter the whole cooling medium flow goes on to the fourth pipe 14 and 5 passes through the retarder cooler 23, the pump inlet 15 and the pump 16 for renewed circulation through the engine cooling ducts 3.

Deactivation of the extra pump 25 takes place in a similar manner to that described above with reference to Fig.1.

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The embodiment according to Fig.2 exhibits a further advantage which may be used, in connection with starting the engine, to speed up the warming up of the engine to normal operating temperature. At the time of starting the engine, the cooling medium temperature is low and the thermostat will direct the cooling medium through the bypass pipe 9, since there 15 is no cooling requirement. It is assumed that the retarder 2 is not activated at the time. The driver's activation of a special warming-up function in the control system (not depicted) of the retarder 2 causes the retarder to exert a braking effect at the same time as the vehicle is otherwise being driven normally. In this case, however, there is no activation of the extra pump 25. This results not only in the retarder 2 exerting a braking effect which increases the 20 load on the engine and thereby speeds up the warming up, but also in the heat generated in the retarder being imparted directly in the retarder cooler 23 to the cooling medium, the passage of which through the engine cooling ducts 3 speeds up the warming up of the engine.

25 The risk of boiling means that in this warming-up programme the retarder 2 cannot be made to exert a full braking effect. This warming-up function is stored as a programme in the retarder control system and this control system is also connected to the pump control unit 26. No further description of this warming-up function will be given here, as it does not directly form part of the invention.

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The invention may assume alternative embodiments within the scope of the patent claims attached. The description and the patent claims indicate that the retarder cooler 23 is connected to the inlet 10 and outlet 12 of the radiator 11. This inlet 10 and outlet 12 denote

not only what is arranged on the actual radiator 11 but also the pipes 8, 13 which are connected respectively to the inlet 10 and outlet 12, or other pipes which may be used for corresponding connections.

- 5 According to the description, a sensor 21 and a control unit 26 are used for detecting activation of the retarder 2 and for causing operation of the second pump 25. In a simple embodiment these components may also take the form of simple components, e.g. the sensor may take the form of the control which the driver uses for activating the retarder and the control unit may take the form of a simple relay. Both the control unit 26 and the sensor 21  
10 therefore may not always take the form of components which are usually referred to by these expressions, but may take the form of any components which function in a similar manner.

- In both of the embodiments exemplified above, the extra pump 25 was assumed to be driven by an electric motor and the control unit 26 controlled the operation of the pump by  
15 controlling the electric motor. In an alternative embodiment the pump need not need not be driven by an electric motor. Instead, it may be operated by the pump 25 being connected to another driving device which causes the pump to operate during the time when the retarder is activated. Such a driving device may for example consist of a driving power connection with the vehicle transmission, e.g. with the output shaft from the vehicle gearbox or with a  
20 power take-off on the gearbox. Such a driving power connection should at the same time incorporate a releasable connection such as an electromagnetic clutch to facilitate activation and deactivation of the pump in a similar manner. A control unit similar to what has been described is then used to activate the electromagnetic clutch to bring the extra pump into operation on activation of the retarder. All that is really essential is that activation of the  
25 retarder also somehow causes activation of the extra pump during the time when the retarder is activated.

**Patent claims**

1. Cooling system for an engine-driven vehicle equipped with retarder and incorporating an engine cooling circuit for cooling the vehicle engine (1) and a retarder cooling circuit (24) for cooling the retarder (2), in which the engine cooling circuit incorporates an engine radiator (11), a first cooling medium pump (16) for circulation of cooling medium through the engine cooling ducts (3) and a thermostat housing (7) containing a thermostat which detects the cooling medium temperature in order, in a manner dependent on the latter, to direct the cooling medium through the engine radiator (11) and/or through a bypass pipe (9) bypassing the engine radiator (11), and in which the retarder cooling circuit (24) incorporates a retarder cooler (23) intended to transfer heat engendered in the retarder (2) during braking operations to the cooling medium, characterised in that the retarder cooling circuit (24) consists of a circuit which is parallel with the engine radiator (11) and is connected on the one hand to the inlet (10) of the engine radiator (11) and on the other hand to the outlet (12) of the engine radiator (11), that the radiator cooling circuit (24) incorporates a second cooling medium pump (25) and that the second cooling medium pump (25) is connected to a driving device which is arranged to cause the second pump (25) to operate during the time when the retarder (2) is activated.
- 20 2. Cooling system according to patent claim 1, characterised in that the operation of the second pump (25) takes place under the influence of a control unit (26), that the control unit (26) is connected to a sensor (21) which detects activation of the retarder and that the control unit (26) is arranged to cause the second cooling medium pump (25) to operate during activation of the retarder.
- 25 3. Cooling system according to patent claim 1 or 2, characterised in that the second cooling medium pump (25) is driven by an electric motor or a hydraulic motor.
4. Cooling system according to patent claim 2, characterised in that the second pump (25) is connected to the transmission of the vehicle via a driving power transfer connection which incorporates a clutch controlled by the control unit (26).
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5. Cooling system according to any one of the foregoing patent claims,  
characterised in that the second cooling medium pump (25) has an outlet  
connected directly to the inlet (27) of the retarder cooler (23).

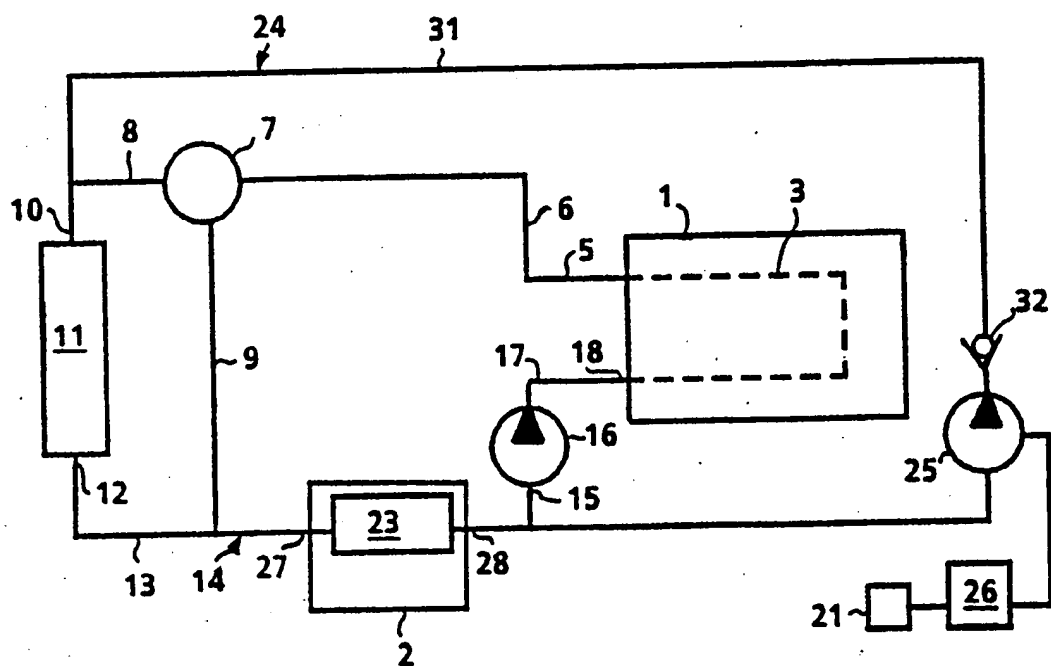
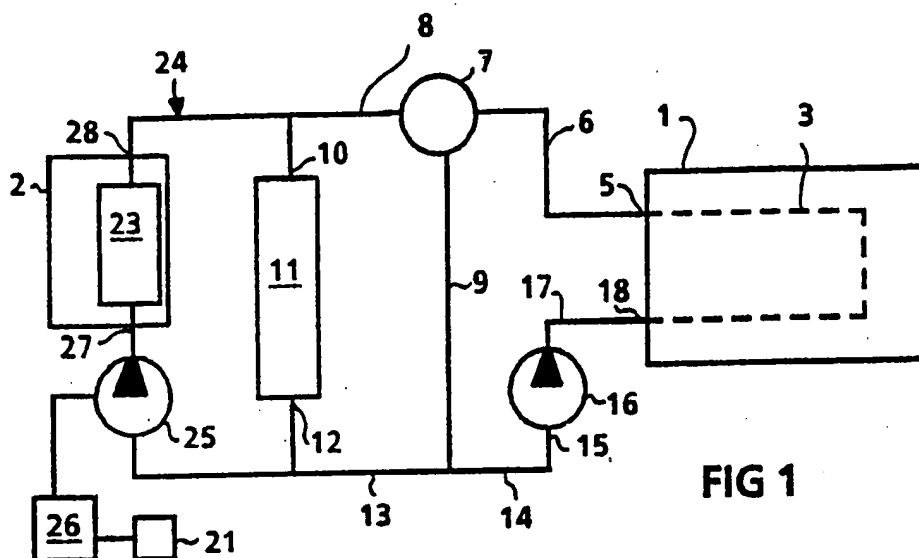
5 6. Cooling system according to any one of the foregoing patent claims,  
characterised in that the retarder cooler (23) is situated in a pipe (14) which is  
common to the engine cooling circuit and which at the retarder cooler outlet (28) is  
connected both to the inlet (15) of the first cooling medium pump (16) and to the inlet of  
the second cooling medium pump (25).

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7. Cooling system according to any one of the foregoing patent claims,  
characterised in that the retarder cooling circuit (24) incorporates a check valve  
(32) which blocks flow through the retarder cooling circuit (24) in a direction opposed  
to the normal direction of flow of the second pump (25).

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8. Cooling system according to any one of the foregoing patent claims,  
characterised in that the second cooling medium pump (25) is of displacement  
type which at standstill blocks the flow of cooling medium through the pump (25).



## A. CLASSIFICATION OF SUBJECT MATTER

IPC<sup>6</sup>: F01P 3/20

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC<sup>6</sup>: F01P, F16D, B60T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## CLAIMS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent's abstract, No D0606 K/09, week 8309, ABSTRACT OF SU, 922301 (MINSK CAR WORKS), 23 April 1982 (23.04.82) --	1-8
A	Patent Abstracts of Japan, Vol 12, No 55, M-669, abstract of JP, A, 62-200040 (HINO MOTORS LTD), 3 Sept 1987 (03.09.87) --	1-8
A	US, A, 4430966 (MARANDET ET AL), 14 February 1984 (14.02.84) --	1-8
A	US, A, 3190272 (E.J. FALK), 22 June 1965 (22.06.65) --	1-8

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

10 October 1994

Date of mailing of the international search report

12-10-1994

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00646

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 2541227 (H.J. FINDLEY), 13 February 1951 (13.02.51)  -----	1-8

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

27/08/94

International application No.  
PCT/SE 94/00646

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		JP-A-	58002415	08/01/83
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US-A- 3190272	22/06/65	NONE		
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US-A- 2541227	13/02/51	NONE		
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